Study of changes in Electromyographic Activity of Muscles after Therapeutic Exercises in Workers with Lateral Epicondylitis

A

Synopsis

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1.0 Introduction

Occupational tasks, having higher job demands than human capability, may cause various disorders including those related to musculoskeletal system of workers, which are referred to as work-related musculoskeletal disorders (WMSDs). WMSDs affect tendons, cartilage, nerves and muscles and are often caused by activities which involve force, awkward postures, repetition etc. Such activities are commonly present in an assembly line work and other occupations jobs. WMSDs are a major concern in industry which can also compromise competitiveness due to costs related to workers' compensation, labour turnover, absenteeism, poor quality and reduced productivity [1]. Lateral epicondylitis (LE), a WMSD of upper limb, has a high prevalence in many countries [4, 14, 26]. LE has also been well studied for Indian population [8, 16, 31].

LE is defined as an injury at the insertion of the extensor carpi radialis brevis and the extensor digitorum and is characterised by pain and decreased strength during gripping [6, 7]. It is mostly associated with physical work related factors among males and females to combination of higher physical work and lower social support. LE occurs often in repetitive upper extremity activities such as computer use, heavy lifting, forceful forearm pronation and supination, and repetitive vibration. People with repetitive one-side movements in their jobs such as electricians, carpenters, gardeners, and desk bound jobs are also exposed to the risk of LE [23, 32, 34]. LE is difficult to treat and prone to recurrence, and can last for several weeks or months with typical episode of average duration between six months and two years [11]. To examine the severity of the lateral epicondylitis or tennis elbow, dynamometer, visual analogue scale (VAS) and a patient-rated tennis elbow evaluation questionnaire (PRTEEQ) are commonly used [18, 25]. The dynamometer is used to measure grip strength [19]. A VAS is a scale that attempts to measure the amount of pain that a patient feels and it ranges

across a continuum from none to an extreme amount of pain [12]. The simplest VAS is a straight horizontal line of fixed length, usually 100 mm. The ends are defined as the extreme limits of the parameter to be measured (symptom, pain, health) [29]. PRTEEQ is a 15-item questionnaire, and is designed to measure forearm pain and disability in patients with lateral epicondylitis. The patients have to rate their levels of tennis elbow pain and disability from 0 to 10. PRTEEQ consists of 2 subscales. There is a pain subscale (0 = no pain, 10 = worst imaginable) and the function subscale (0 = no difficulty, 10 = unable to do). Specific exercises to stretch and strengthen the muscles attached to the injured tendon may help with the healing process. The early goal of a therapeutic exercise program is to promote muscle endurance and improve resistance to repetitive stress. Following a well-structured program will help patients/workers return to daily activities, as well as sports and other recreational past times. In the proposed research work we intend to study the change in electromyographic activity of concerning muscles in occupational workers with LE after therapeutic exercises followed by pre and post assessment of pain and to design a rehabilitation program for workers.

1.1 Electromyography

Electromyography (EMG) is a concept related to electrophysiology, an area encompassing the electrical activities in the body. It is a method of signal detection based on the changes in electrical potentials of striated muscles. Electromyographic readings are not easy to interpret, because they are influenced by many factors. The quality of the used equipment and the high complexity of muscles in the body hinder unambiguous determination of where the registered signal comes from. Apparatus consisting of cables connecting electrodes with the signal amplifier restricts the freedom of movement, impeding the research [5]. Surface electromyography, which is more commonly applied, is free of these defects. Electrodes

placed on the skin surface carry no risk of infection, do not cause pain or unpleasant adverse effects, and do not require medical supervision [9]. EMG provides data for individual muscles. To understand EMG, it may be noted that all living cells are surrounded by a membrane, which is selectively permeable to various ions and also actively transports ions, and therefore there exists a resting membrane potential. This potential is typically in the order of -70 to -90 millivolts (mV) for an axon or muscle fiber, with the outside positive relative to the inside. A depolarization of a cell to a threshold value initiates an action potential as the membrane's permeability changes. When generated in a motor nerve neuron, the nerve action potential (NAP) propagates along the cell's axon down to the motor endplate. A series of NAPs over time is referred to as a NAP train. At the motor endplate the NAP train causes the release of chemical transmitters that activate depolarization of the muscle fibers. When the NAP propagates down the motor neuron it normally activates all its branches, and these in turn activate all the muscle fibers of the motor unit. When the muscle fiber membrane is depolarized, the depolarization propagates in both directions along the fiber, causing a wave of contraction that produces a brief twitch and subsequent relaxation. The depolarization of the muscle fiber membrane represents a small electrical potential known as a muscle action potential (MAP), and a series of these over time is called a MAP train. Since not all muscle fibers of a motor unit depolarize and contract simultaneously, a complex motor unit potential (MUP) results from the superimposition of several muscle fiber MAPs. By placing an electrode either within the muscle (i.e., an indwelling or intramuscular electrode) or on the skin (i.e., a surface electrode), these potentials can be recorded. Such measurement is called electromyography (EMG). Each muscle has a number of motor units. An increase in tension can occur either by an increase in the stimulation rate of a given motor unit or by the recruitment of additional motor units. Thus, the recorded EMG voltage is normally the sum of several MUPs.

1.2 Therapeutic Exercises

Therapeutic exercises refer to a wide range of physical activities that focuses on restoring and maintaining strength, endurance, flexibility, stability and balance. The goal of therapeutic exercises is to return an injured patient to a fully functioning, pain-free state. The first objective of therapeutic exercise is to help the body reduce pain and inflammation. Once this is achieved, the exercise program focuses on regaining range of motion and rebuilding muscle strength and endurance. Exercises that may be included in a therapeutic program include (i) strengthening exercises, usually performed with heavy resistance and fewer repetitions, (ii) endurance exercises that engage large muscle groups over a longer period of time, and (iii) flexibility exercises achieved through stretching and movement.

2.0 Literature review

Upper limb WMSDs are an umbrella term for a range of specific disorders to the upper limb, such as carpal tunnel syndrome, tendinitis, or lateral epicondylitis with common work-related risk factors such as repetition, forceful exertion, and awkward postures. Jobs that are highly repetitive, where more than 50% of the time is spent performing the same type of fundamental task, have a 2.8 odds ratio of injury compared to low repetitive jobs [27]. Additionally, if the tasks required in a job are highly repetitive (cycle time less than 30 seconds or more than 50% of the cycle time involved in the same fundamental cycle) and require high force (average hand force requirement of more than 4kg), the odds ratio increases to 30.3 [27]. A cross-sectional study [24] found an evidence of work-related musculoskeletal disorders in 54% of the 146 female workers with highly repetitive jobs (cycle time less than 30 seconds or more than 50% of the cycle time involved in the same fundamental cycle). Symptoms of LE include pain around the lateral side of the elbow, attenuated forearm extension forces, and pain while grasping or wrist dorsiflexion when performing regular activities of daily living [28]. The

prevalence of LE increases with age, and is highest in individuals between 40-60 years old. It is also more common in the dominant elbow than the non-dominant elbow, indicating that physical load factors play a role in the development of LE [26]. Lateral epicondylitis causes functional disability and has high costs due to loss in productivity and increase in health-care use. The length of sick leave due to this condition is around 1-2 weeks, with 10-30% of individuals having a prolonged duration of sick leave up to 11-12 weeks. In rare cases, work disability extends up to 1 year or over, and can cause job changing in strenuous jobs [26]. In a meta-analysis of 20 LE papers [2], it was concluded that there is strong evidence of an association between LE and exposure to repetitive forceful movements that include but are not limited to repeated flexion of the wrist in addition to pronation and supination of the forearm. Performing highly repetitive tasks at least half of the time and working with the hands lifted in front of the body have also been found to increase the risk of developing LE [13]. While it is not explicitly stated, it is inferred that the hands were in the anterior-posterior plane of movement. Additionally, even after adjusting for the personal and work-related psychosocial factors, a significant association has been found between the frequency of forceful exertion and lateral epicondylitis [10].

Surface electromyography (EMG) is commonly used in biomechanics and kinesiology as an indication of the initiation and magnitude of muscle activation. There is also a relationship between the EMG signal and the force produced by a muscle [7]. A study [3] investigated changes in muscular activity and strength of subjects diagnosed with LE, assessed the appropriateness of these measures in the patient's follow-up, and concluded that the use of the pain free grip with the elbow in extension is the most indicated strength measurement to monitor the recovery of patients with LE. Another study [20] investigated to measure maximum forearm supination and pronation torques for variations of elbow and forearm angles, examined mean muscular activity of the prime superficial forearm pronators,

supinators, the deltoid and the extensor carpi radialis brevis (ECRB) for maximum forearm torques at each of the joint angle combinations, and concluded higher muscular activity in the ECRB for both supination and pronation torques. This study also suggested that the ECRB acted as a stabiliser to the forearm flexors for gripping during pronation torques depending on forearm angle, but acted as a prime mover in wrist extension for supination torques with little effect of elbow and forearm angle.

Many therapeutic interventions have been used in the treatment of LE, but no specific intervention has proved universally efficacious [15, 21]. A study [22] assessed the long term outcome of progressive exercises and local term follow-up evaluation of patients using pain questionnaire. The progressive exercises showed beneficial long term effects compared to ultrasound treatment in terms of pain alleviation and working ability. A combination treatment of progressive strengthening and stretching exercises was found more effective than pulsed ultrasound in treating chronic LE in a study [30]. A study [31] demonstrated that progressive strengthening exercises along with conventional physiotherapy are more effective in relieving pain, improving functional disability and improving pain free maximal isometric grip strength than conventional physical therapy alone in patients having chronic LE. Another study [33] identified key factors associated with outcomes of patients who underwent 8 weeks of physical therapy (PT) for lateral epicondylitis. The final score of the disability of the arm, shoulder and hand (DASH) questionnaire and a pain visual analogue scale (VAS) were used as dependent variables. This study concluded that women and patients who reports nerve symptoms are more likely to experience a poorer short term outcome after PT management of lateral epicondylitis. Work related onsets, repetitive keyboarding jobs, and cervical joint signs have a prognostic on women.

3.0 Proposed Research Work

It is proposed to perform electromyographic analysis and dynamometry test to investigate change in muscular activity and strength of occupational workers (subjects). An inclusion and exclusion criterion of subjects is illustrated in (Table 1). These subjects would be evaluated at baseline, during supervised therapeutic exercises (TEs) for six weeks and after three months to see any carryover effects. Demographic data (name, age in years, height in centimetres, weight in kilograms and work-experience in years) of each subject would be recorded. Body mass index would also be calculated using height and weight data of each subject. The evaluation will include: the patient rated tennis elbow evaluation, a visual analogue scale, pain free grip, maximal isometric strength of wrist and surface EMG. To evaluate the relative effectiveness of TEs, we may perform EMG analysis initially on healthy subjects. The normalization of the dynamic movements of each TE is done to a dynamic maximum. Each muscle data will be normalized with respect to the maximum EMG activity recorded during an experimental test for that muscle. This type of normalization helps in assuring constancy for normalization within each muscle, and assures that the reliability of normalization is based on a dynamic movement. All subjects would perform a few repetitions (or trials) of each exercise. EMG data during middle trials are usually considered for the analysis, and the remaining trials may be excluded. The speed of the repetitions will be controlled by a computerized metronome set to a value in beats per minute. Sampling of the EMG data may be done at 1,000 samples per second. EMG data will be amplified 2,000 times by the Tel-100 system of Biopac MP 150. The EMG signals will be band-pass filtered with cut off frequency as 20 to 500 Hz using AcqKnowledge 4.1 Software, Biopac Systems, Inc. USA. These signals may be full-wave rectified and integrated using MATLAB Software, The Mathworks, Inc. The process of obtaining EMG signals will be repeated for each muscle.

TEs resulting in higher activity of identified muscles in healthy subjects can be selected for their use to patients diagnosed with LE. A brief demonstration of equipment (e.g. EMG machine, dynamometer etc.) and selected exercises would be given to subjects. Informed consent would also be obtained from each subject prior to experiments. The VAS will be measured with a scaled line from zero to one hundred millimetres. Then subjects will be asked to mark with an X the location on the line below which best represents the intensity of their pain. The PRTEE with a score from zero to one hundred will be used. This questionnaire will provide a brief, uncomplicated, and standardised quantitative description of pain and functional disability. PFG will be done to quantify the progression of LE and will be measured by using a dynamometer. The test will be performed by the subjects in two standard positions: the arm along the body with the elbow bent at 90 degrees and the elbow in full extension along with the body. The surface EMG of identified muscles (e.g., the extensor carpi radialis, the extensor digitorum and the superficial flexor digitorum) will be recorded during maximum and sub maximal isometric contractions in flexion and extension of the wrist.

Inclusion criteria	**Exclusion Criteria**
• Participants between 20 - 60 years of age referred from physicians or physiotherapists or self-referred, with lateral elbow pain for more than 2 months, reproduced by resisted wrist and/or middle finger extension and tenderness over the lateral epicondyle	• Bleeding disorders (hemophilia) • Taking anticoagulants (aspirin) • Disease of the central or peripheral nervous system • Diabetes • Kidney disease • Uncontrolled hypertension, • The presence of an infection at the time of the evaluation • History of elbow surgery or diffuse pain syndrome (e.g. fibromyalgia) • Elbow osteoarthritis, rheumatoid arthritis, or other inflammatory arthritis affecting the wrist or the elbow • Carpal tunnel syndrome • Fracture of the upper limb with residual deformity

Table 1: Inclusion and Exclusion criteria

4.0 Objectives

1. To evaluate the effects of therapeutic exercises in alleviating elbow pain in occupational workers diagnosed with lateral epicondylitis.

2. To compare EMG activity of identified muscles (e.g., the extensor carpi radialis, the extensor digitorum and the superficial flexor digitorum) across two sets of subjects, viz. (i) patients and (ii) healthy subjects.

3. To evaluate pain free grip (PFG) and maximal isometric strength at baseline, after 6 weeks of supervised TEs and after three months of unsupervised TEs.

4. To evaluate patients with LE using visual analogue scale (VAS) as well as patient related tennis elbow evaluation (PRTEE).

5.0 Schedule of the Proposed Research

1. Initial survey and data collection: 3 months
2. Experimental studies to record activity of muscles of different subjects in the lab during exercises: 15 months
3. Analysis of results: 6 months
4. Detailed discussion of results and submission of research work in peer reviewed journal/conference: 6 months
5. Thesis writing: 6 months

6.0 Conclusion

The proposed research work would be useful in designing appropriate rehabilitation programs for patients with lateral epicondylitis.

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